

Lunar Meteorite Impact Risks



A December 4, 2006 CNN.Com news story, based on the research by Bill Cooke, head of NASA's Meteoroid Environment Office suggests that one of the largest dangers to lunar explorers will be meteorite impacts. Between November 2005 and November 2006, Dr. Cooke's observations of lunar flashes (see image) found 12 of these events in a single year. The flashes were caused primarily by Leonid Meteors about 3-inches across, impacting with the equivalent energy of 150-300 pounds of TNT.

The diameter of the moon is 3,476 kilometers.

Problem 1: From the formula for the surface of a sphere, A) what is the area, in square kilometers, of the side of the moon facing Earth? B) What was the average impact area for a single event?

Problem 2: Assuming the area is a square with a side length 'S', A) what is the length of the side of the impact area? B) What is the average distance between the centers of each impact area?

Problem 3: If the impacts happen randomly and uniformly in time, about what would be the time interval between impacts?

Problem 4: From the vantage point of an astronaut standing on the Moon, the horizon is about 3 kilometers away. How long would the lunar colony have to wait before it was likely to see an impact within its horizon area?

Answer Key:

Problem 1: From the formula for the surface of a sphere, A) what is the area, in square kilometers, of the side of the moon facing Earth? B) What was the average impact area for a single event?

Answer: A) $2 \times 3.141 \times (1738 \text{ km})^2 = 1.89 \times 10^7 \text{ km}^2$ and B) $1.89 \times 10^7 \text{ km}^2 / 12 = 1.58 \times 10^6 \text{ km}^2$

Problem 2: Assuming the area is a square with a side length 'S', A) what is the length of the side of the impact area? B) What is the average distance between the centers of each impact area?

Answer: A) $S = (1.58 \times 10^6 \text{ km}^2)^{1/2}$ about 1,257 kilometers B) 1,257 kilometers.

Problem 3: If the impacts happen randomly and uniformly in time, about what would be the time interval between impacts?

Answer: 1 year / 12 impacts = One month.

Problem 4: From the vantage point of an astronaut standing on the Moon, the horizon is about 3 kilometers away. How long would the lunar colony have to wait before it was likely to see an impact within its horizon area?

Answer: 1 impact per 1.58×10^6 square kilometers per month. The area of the horizon region around the colony is about $\pi \times (3\text{km})^2 = 27$ square kilometers. This area is $1.58 \times 10^6 \text{ km}^2 / 27 \text{ km}^2$ or about 60,000 times smaller than the average, monthly impact area. That suggests you will have to wait about 60,000 times longer than the time it takes for one impact or 59,000 months, which equals 4,000 years, assuming that the distribution of impacts is completely random, unbiased and has a uniform geographic distribution.